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Investment risk in the energy sector on the example of a biogas power plant

Risk contains uncertainty.

The energy sector is dynamic:

- high capital intensity
- big impact on the (entire) economy.

Directed Technical Change, Capital Intensity Increase and Energy Transition: Evidence from China

Dong Wang, Amin Mugera,** and Ben White****

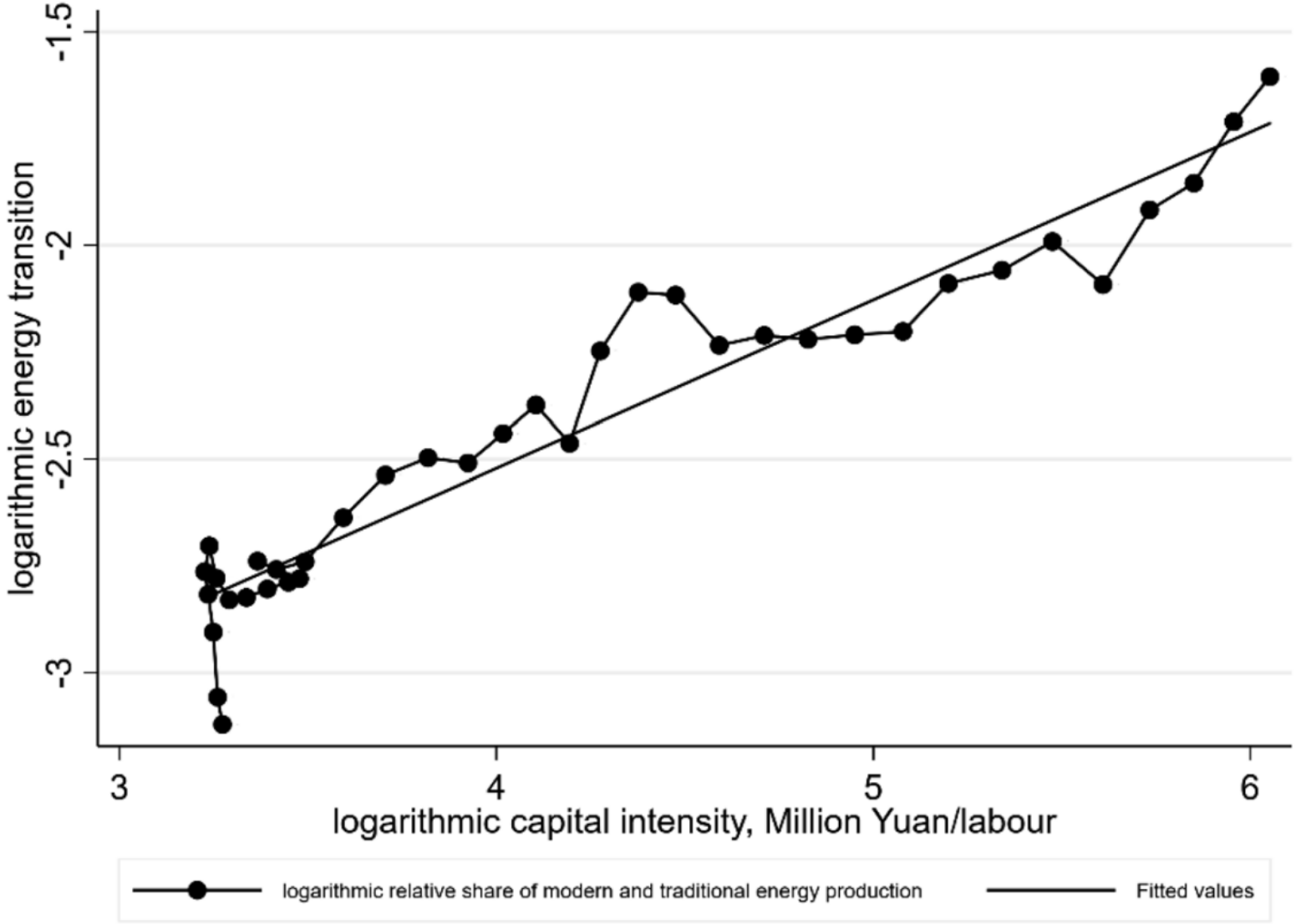
ABSTRACT

This paper analyses the causes of China's energy transition since 1978 when the economic reform policy was launched. We aim to determine if increasing capital intensity in the Chinese economy is driving a shift in the energy mix towards modern energy sources, such as solar electricity. The empirical investigation is based on national level time series data from 1978 to 2015. The results of a Granger Causality test show that increasing capital intensity causes transition to modern energy in the long run, but not *vice versa*. The impulse-response analysis, based on the Johanson cointegration and vector error correction model (VECM), verifies that capital intensity determines energy transition in the long-run and the adjustment period to an exogenous shock from capital intensity is around five years. This is in line with China's National Five-year Plans which often introduce major shifts in energy and industrial policy. We conclude China's energy transition is driven by capital deepening and biased technical change towards capital-intensive modern energy in the long run. The rate of change is increased by exogenous investment shocks partly as a result of policy initiatives introduced by China's Five Year Plans.

Keywords: Energy transition, Capital intensity, VECM; Granger test

https://doi.org/10.5547/01956574.40.SI1.dwan

Figure 4: Energy transition and capital intensity



Paper examines the investment risk in the energy sector.

Two important methods are used:

- Net Present Value (NPV)
- Internal Rate of Return (IRR).

Risk sources (difficult to analyze separately):

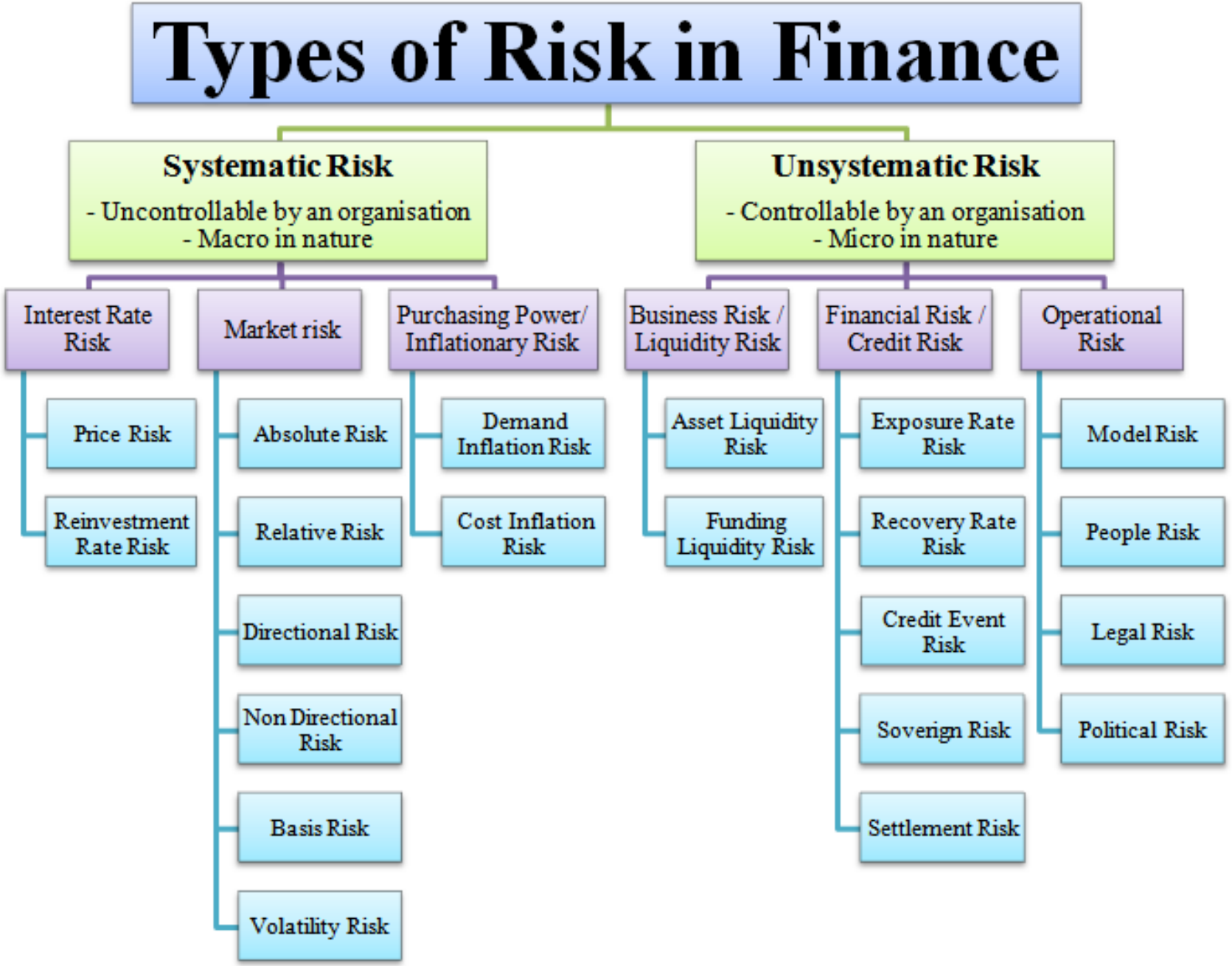
- Microeconomic factors
  - company
- Mezoeconomic factors
  - industry
- Macroeconomic factors
  - politics, world trends.

Sources of Risk (2)

- **Country-Specific Economic risk**
  - *Macroeconomic Risks:*
    - Exchange rate;
    - Hyperinflation;
    - Terms of Trade;
    - Debt Service.
  - *Microeconomic Risks:*
    - *Market Failure;*
    - *Market Inefficiency.*
  - *Supranational Level* → risk of contagion!

Risk type:

- Systematic risk
  - originates from macroeconomic risk groups
  - ever-present, cannot get rid of
  - reduction is possible only to a certain (limited) extent
- Specific (unsystematic) risk
  - due to specific nature of investment.


Types of Risk in Finance
Systematic Risk
- Uncontrollable by an organisation
- Macro in nature
Unsystematic Risk
- Controllable by an organisation
- Micro in nature
Interest Rate Risk
Market risk
Purchasing Power/ Inflationary Risk
Business Risk / Liquidity Risk
Financial Risk / Credit Risk
Operational Risk
Price Risk
Reinvestment Rate Risk
Absolute Risk
Relative Risk
Directional Risk
Non Directional Risk
Basis Risk
Volatility Risk
Demand Inflation Risk
Cost Inflation Risk
Asset Liquidity Risk
Funding Liquidity Risk
Exposure Rate Risk
Recovery Rate Risk
Credit Event Risk
Soverign Risk
Settlement Risk
Model Risk
People Risk
Legal Risk
Political Risk

Market vs. specific risk

Specific Risk
(Unique, residual,diversifiable)

Affects a particular company and can be reduced by diversification

- A competitor patents new technology
- The union at a production plant walks out on strike
- A major new competitor enters the industry

Specific risk should be reflected in the forecasted cash flows, not in the discount rate

Systematic Risk
(Market Risk)

Affects all companies and cannot be reduced by diversification

- Inflation rises unexpectedly
- Political instability, war…
- Federal Reserve raises interest rates
- Industrial or economic cycle changes

Market risk should be reflected in cash flows and the cost of capital. It cannot be diversified away and investors want to be compensated for bearing it

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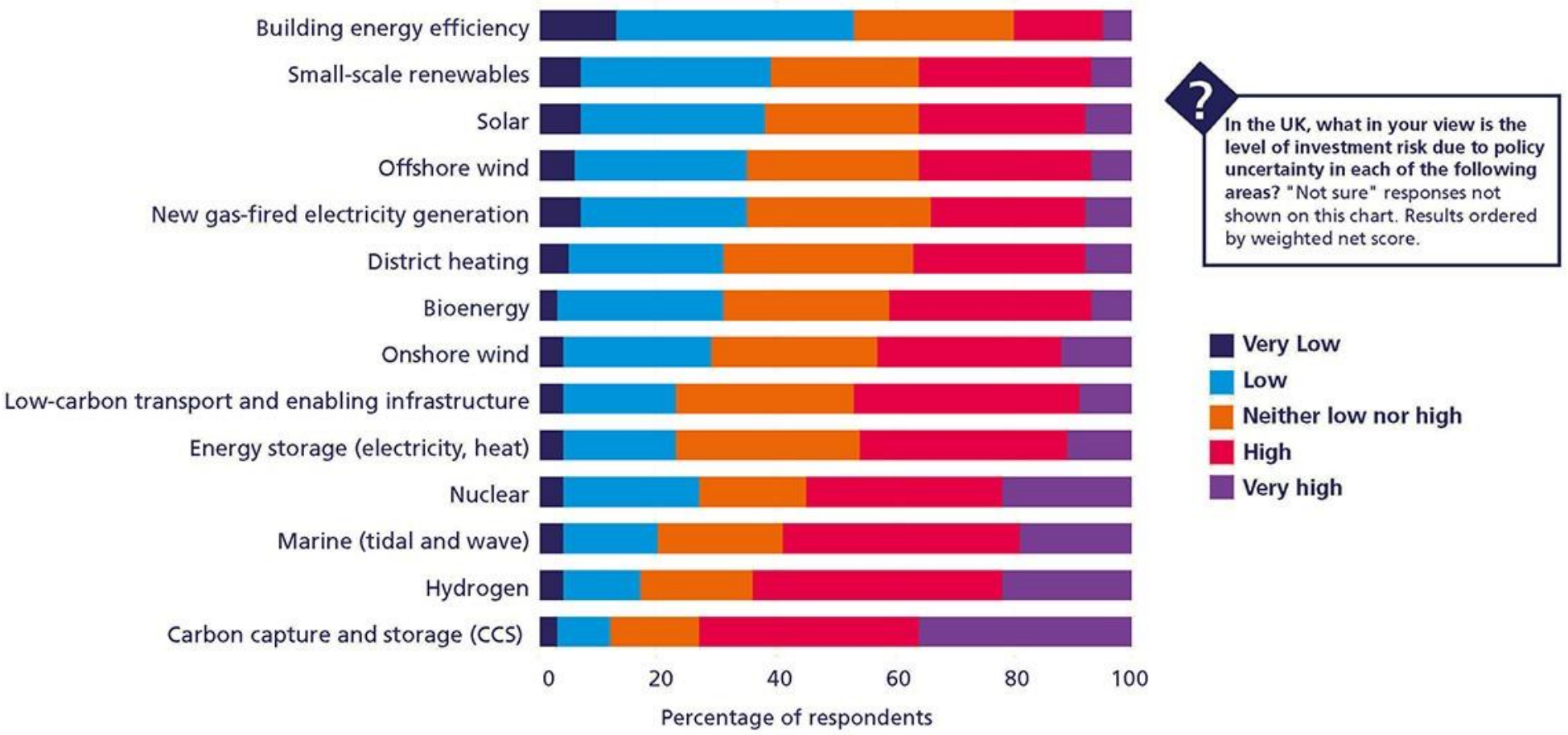
Systematic Risk vs. Specific Risk

- Flood – Systematic Risk -everyone gets wet
- Bucket of water thrown by your brother – Specific risk – only you get wet

- Insuring one House – Systematic or Specific?
- Insuring thousands of houses – Systematic or Specific?

Level of investment risk from policy uncertainty



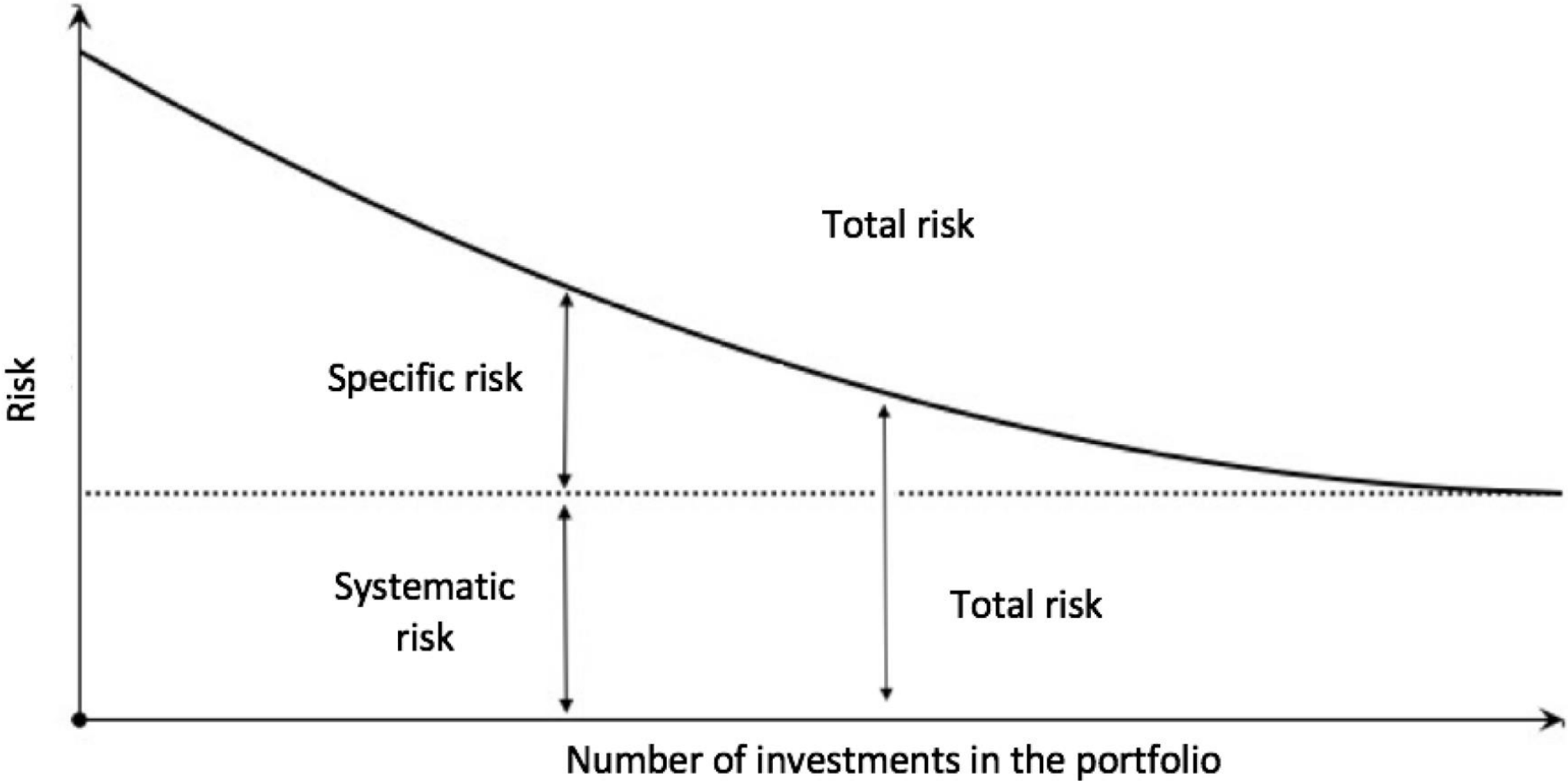
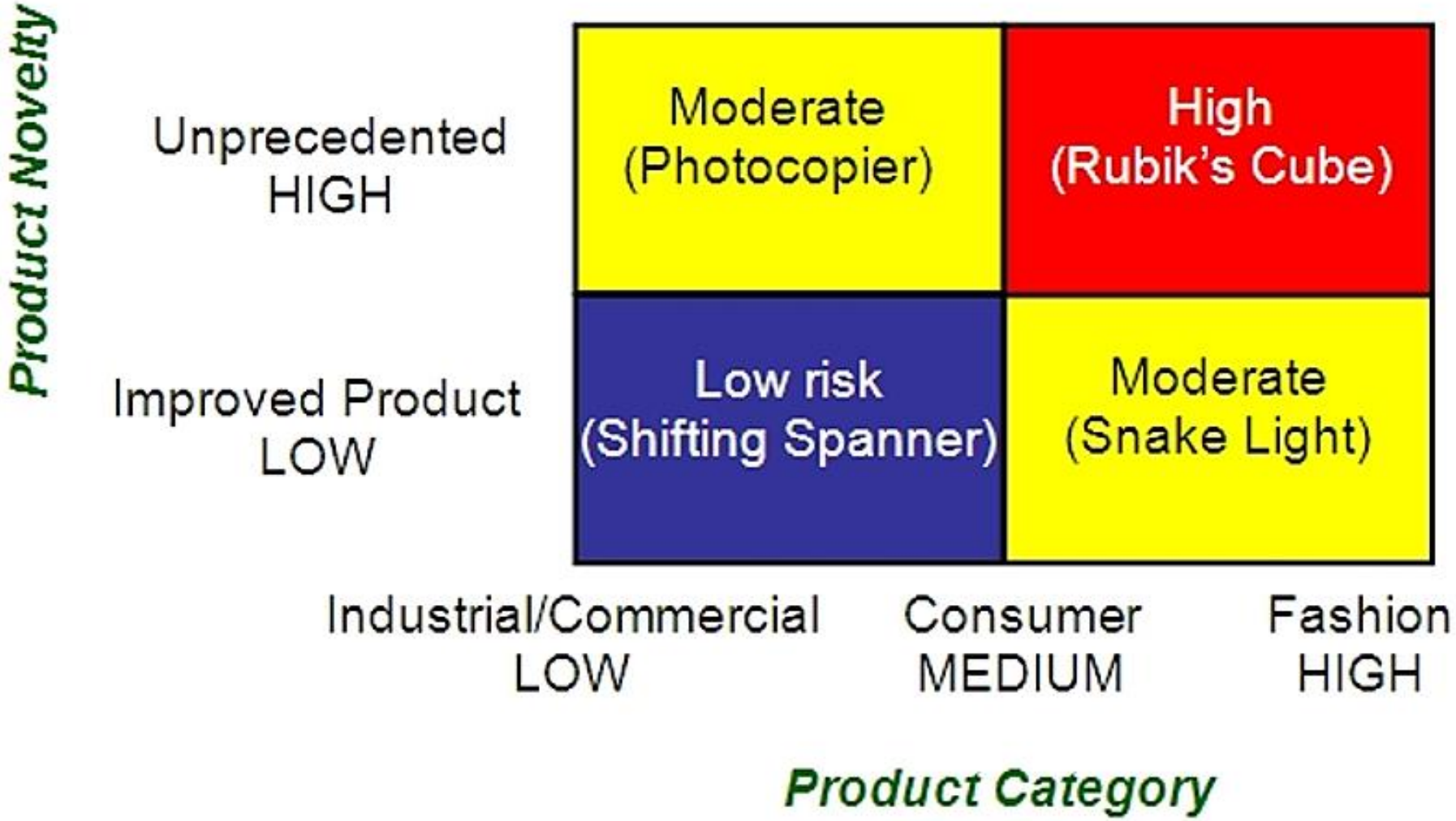


Fig. 1. The impact of diversification on the level of risk (Kryzia 2014)

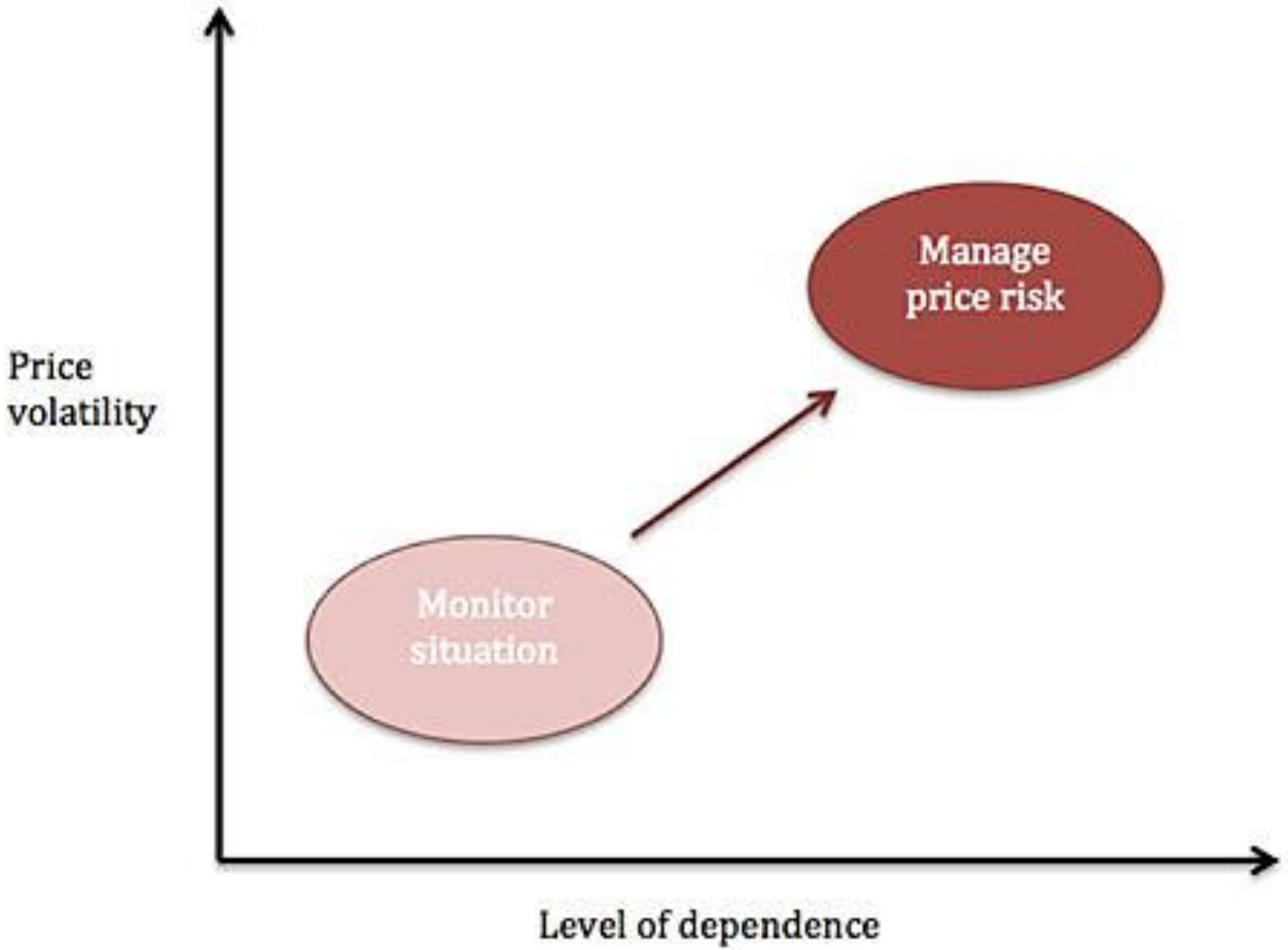
Types of investment risk in the energy sector (depending on specificity and uniqueness of investment):

- Market risk
  - ✖ normally, no single investment affects the balance of a mature market
  - ✖ theoretically, quantity and price determine success
  - ✖ in reality, participation in market may be prevented by competition
  - ✖ such market risk may relate to supply, demand, market competition or price.

Market Risk Map



- Price risk
  - changing price of a product
  - changing cost of components of a product
    - emission allowances
    - price of fuel/energy (electricity)
    - cost of certification
    - cost of labor


Manage price risk
Price volatility
Monitor situation
Level of dependence

- Political risk (*more later*)
  - difficult to estimate and diversify
    - tariff policy
    - regulation policy
    - warranty policy
    - industry regulations
  - legal risk subcategory
    - overregulation, e.g. too many regulations
    - underregulation, e.g. insufficient (legal) description of aspect
    - dynamic legal developments (especially with long-term investments)
  - paper focuses on risks that are marginally political/IR

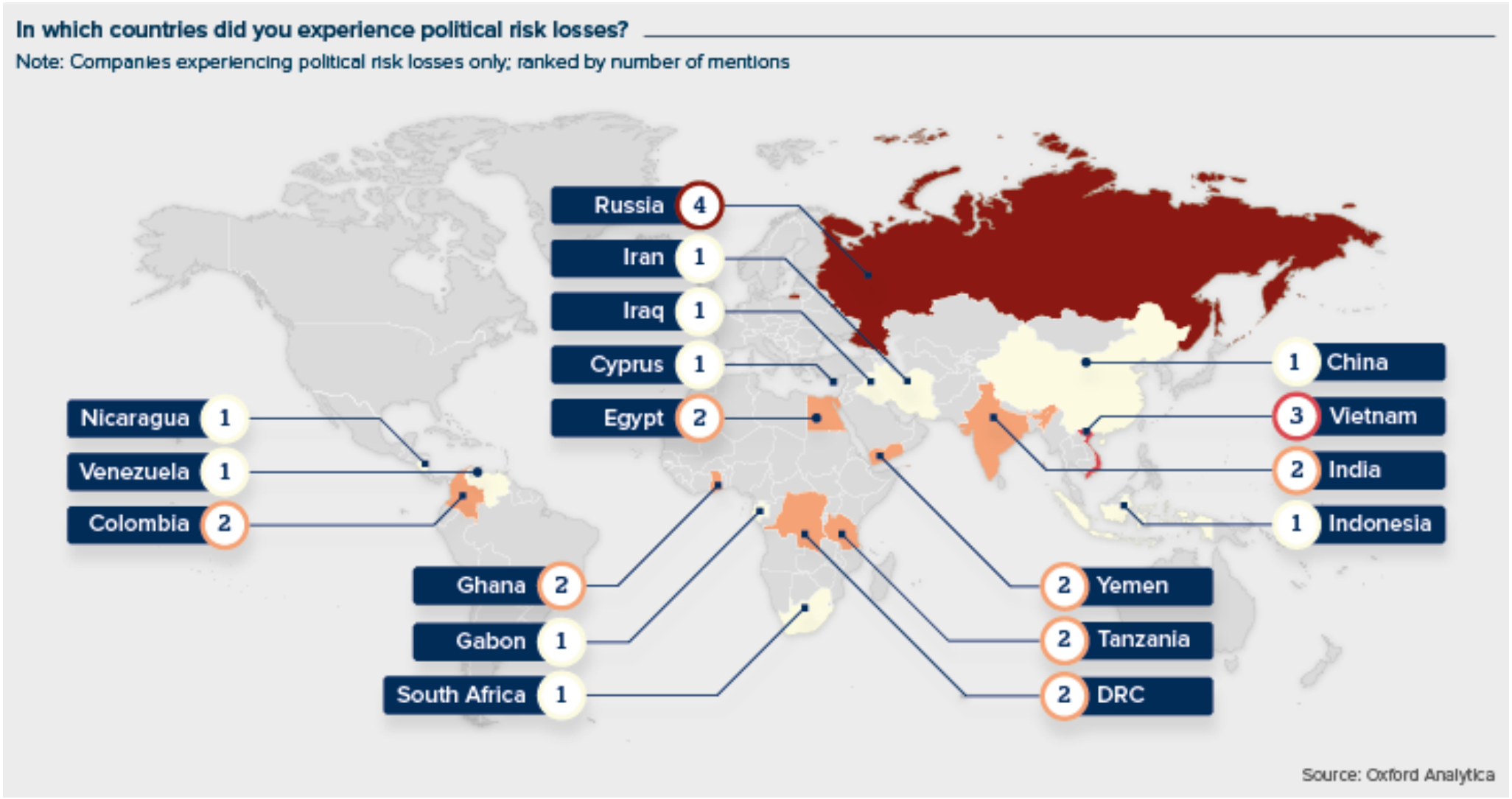
Examples of Political Risk

Below are some examples of political risk and can be broken down into separate Categories:

1. **Macro Risk** - Country Related

2. **Micro Risks** - Sector related

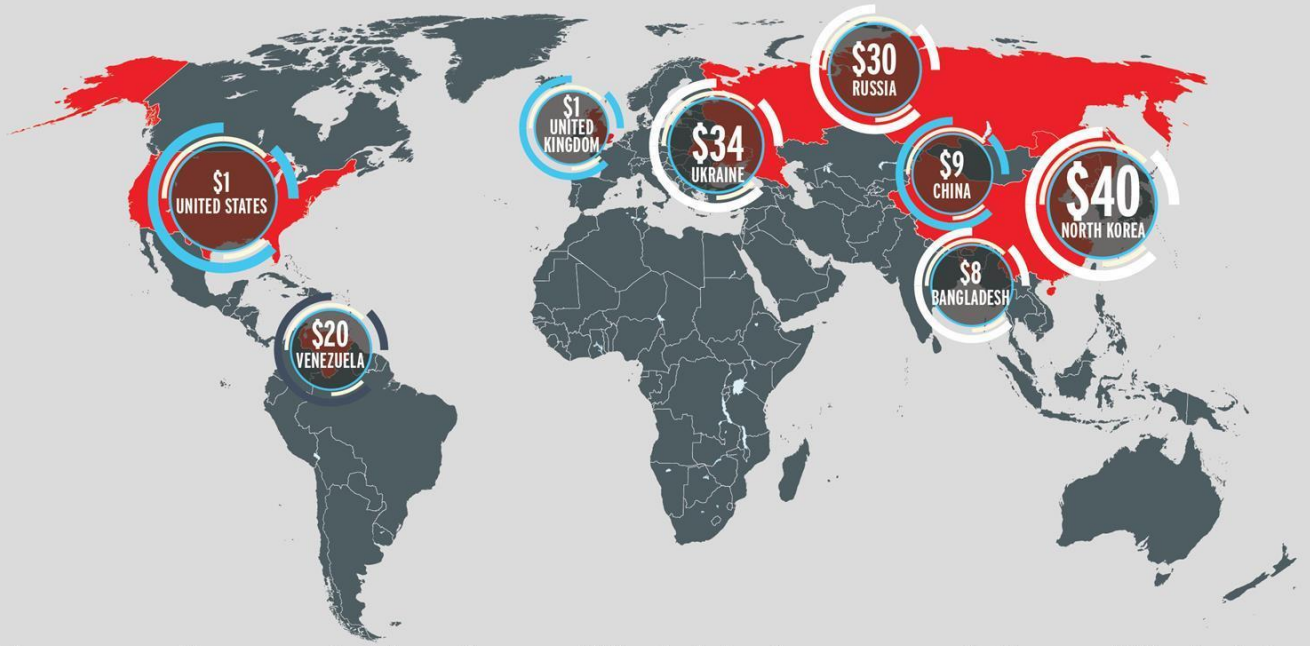
Examples of Risk
- High levels of crime and violence
- Terrorism
- Nationalisation of property
- Disorderly political manifestations, civil unrest and riots
- Armed conflict
- Foreign threat of invasion
- Weak political institutions
- High levels of corruption
- Large and unpredictable changes in government policy


In which countries did you experience political risk losses?
Note: Companies experiencing political risk losses only; ranked by number of mentions
Russia 4
Iran 1
Iraq 1
Cyprus 1
Egypt 2
Nicaragua 1
Venezuela 1
Colombia 2
Ghana 2
Gabon 1
South Africa 1
1 China
3 Vietnam
2 India
1 Indonesia
2 Yemen
2 Tanzania
2 DRC
Source: Oxford Analytica

Willis

WHERE COULD INVESTORS LOSE OUT TO POLITICAL TURMOIL?

Source: Willis and Oxford Analytica VAPOR (Value at Political Risk) model

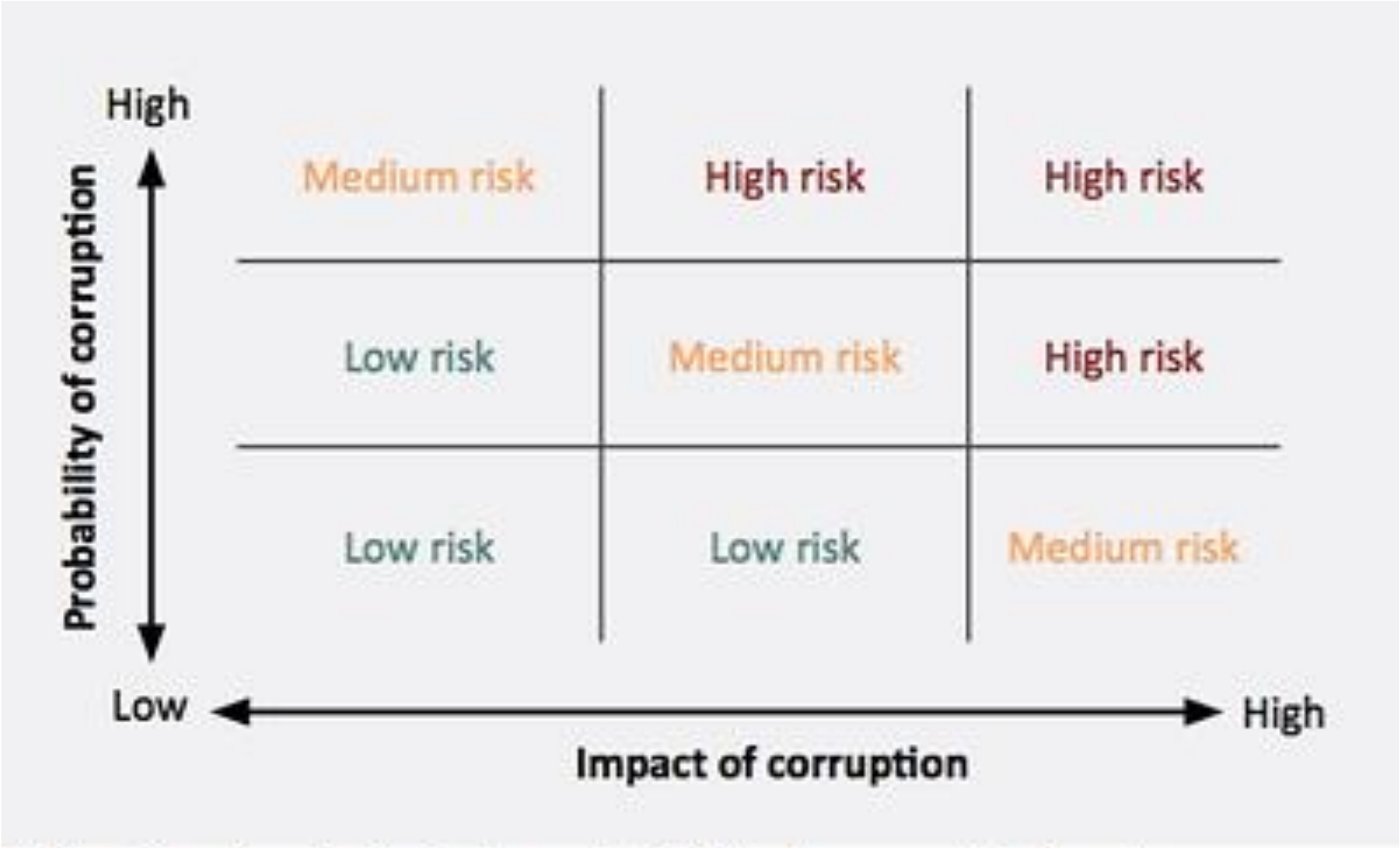


Figures are the expected loss from political risks (e.g. expropriation, political violence and trade sanctions) over a ten year horizon for every $100 of investment.

*North Korea is the riskiest investment destination currently rated by the VAPOR model

- Financial risk
  - investment not being profitable
    - cash flow disturbances
- Operational risk
  - improper management of company resources
    - human
    - technical
    - financial
    - disturbances in internal structure of company
    - dishonesty of employees or shareholders (corruption)


PROCESS
PEOPLE
SYSTEMS
EXTERNAL EVENTS
OPERATIONAL RISK



Estimating level of risk: probability by expected impact

CORRUPTION RISK ASSESSMENT

(Ernst & Young Global Ltd., 'Bribery and Corruption: Navigating the Global Risks', 2012)

- company's geographic location(s)
- business sectors scoped
- business partners + nature of activities & transactions
- interactions between partners & local officials

- Environmental risk
  - impacts on ecosystems
  - can incur social (external) costs or fines
- Construction risk
  - postponing project milestones
  - failure to meet completion schedule
  - may affect financial liquidity
- Technical risk
  - improper operation
  - unavailability (of infrastructure, e.g. power grid, generating unit)

Technical risks

- *Threaten the quality and timeliness of of the software to be produced.*
- *If a technical risk become a reality ,implementation may become difficult and impossible.*
- *Technical risks occur when the problem is harder to solve than you thought it would be.*

- ***Risk factors:***

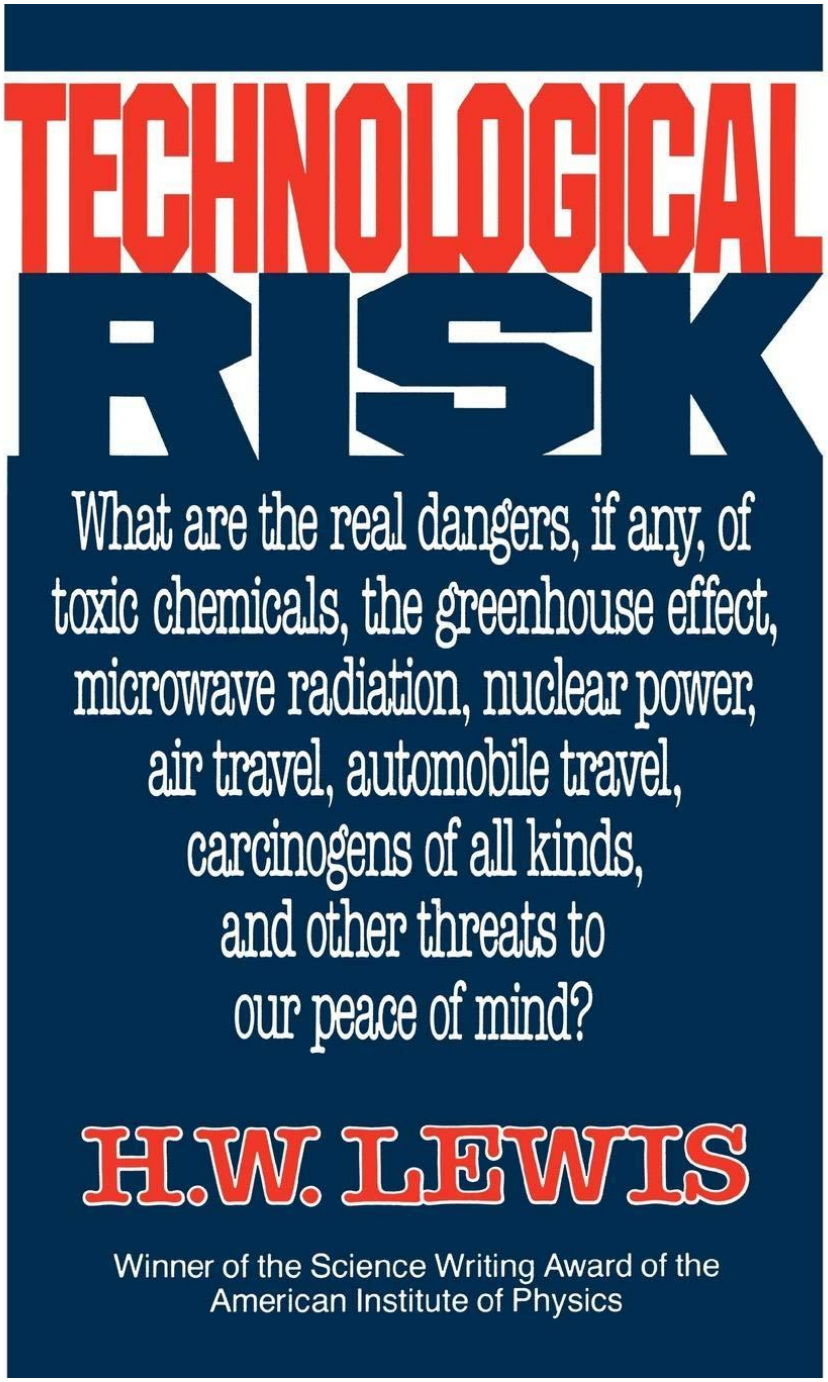
- ***Potential design and implementation***
- ***Interface***
- ***Verification***
- ***Maintenance problems***
- ***Specification ambiguity***
- ***Technical uncertainty***

- Credit risk
  - excessive debt
  - lack of liquidity
  - wrong decision on credit or equity funding
  - large-budget energy infrastructure investments particularly prone to this type of investment risk
- Technological risk
  - inability to find innovative solutions
  - emergence of new more efficient technology

Technological Risks

The contractor

- ✓ Does not assign capable or adequate resources
- ✓ Is not familiar with the existing technology, application area of set up
- ✓ Does not follow a proven methodology
  - ☛ Either in project or technology management
- ✓ Does not use project management techniques
  - ☛ To track progress or identify issues
- ✓ Is not close at hand to facilitate coordination
  - ☛ With the client and the users


TECHNOLOGICAL
RISK
What are the real dangers, if any, of
toxic chemicals, the greenhouse effect,
microwave radiation, nuclear power,
air travel, automobile travel,
carcinogens of all kinds,
and other threats to
our peace of mind?
H.W. LEWIS
Winner of the Science Writing Award of the
American Institute of Physics

Critical risks impacting the energy industry (https://riskandinsurance.com/7-risks-impacting-energy-industry/):

- Global warming/climate change
  - *"One of the biggest contributors to the greenhouse effect causing global warming is fossil fuel emission — of which, 80 percent of the world's energy comes from"*
- Rapidly changing industry
- Cyber threats
  - more when we look at the *history of energy security*
- Regulation and public policy
- Tariffs and trade tension
- Personnel issues (talent retention and new hires)
  - retirement
- Catastrophic events (black swan, *more later*)
  - *"more events, more to them"*.

Methods of risk identification:

- Checklists
  - questions answered by experts
  - success depends on accuracy and completeness of questions
- Delphi method
  - panel of experts from various fields
  - working in isolation is advised
  - collected and systematized results are presented to the group

Delphi defined as….

- An "organized method" for collecting views and information pertaining to a specific area;
- A method that allows dialogue between geographically separated experts while serving an effective means for learning;
- Gathering a group of experts to forecast events and assess complex issues;
- Collective human intelligence;
- A process of exploring… assessing… and evaluating.

The Wisdom of Crowds

- Idea was popularized by a book published in 2004 called *The Wisdom of Crowds* by James Surowiecki
- A diverse collection of independently-deciding individuals is likely to make certain types of decisions and predictions better than individuals or even experts
- The aggregation of information in groups resulted in decisions that are often better than could have been made by any single member of the group
- This book presented numerous case studies that touch several fields, primarily economics and psychology.
- Delphi Method, Prediction Markets, County Fair example

A *NEW YORK TIMES* BUSINESS BESTSELLER

"As entertaining and thought-provoking as *The Tipping Point* by Malcolm Gladwell. . . . *The Wisdom of Crowds* ranges far and wide."
—*The Boston Globe*

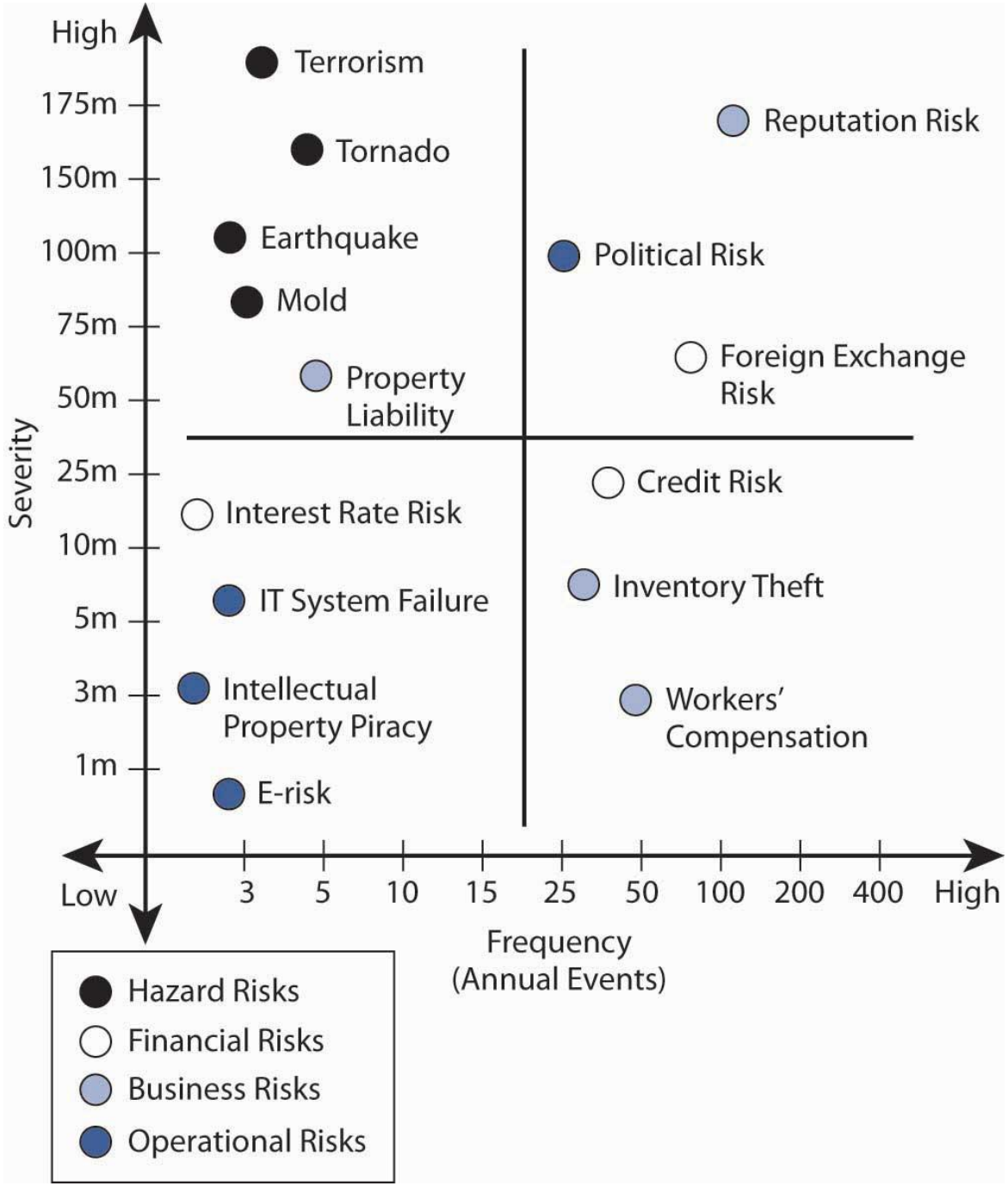
THE WISDOM OF CROWDS

JAMES SUROWIECKI

WITH A NEW AFTERWORD BY THE AUTHOR

- Nominal group technique
  - similar to Delphi method
  - experts work in groups
- Brainstorming and public debate
  - joint discussion on given issue
  - best possible solution sought
  - public debate = special form of brainstorming
    - both supporters and opponents of an investment may be present

- Holistic methods
  - Large drawing analysis
    - legal and technical dependencies
    - interpersonal relations
    - potential conflicts
  - Map of system
    - all potential relationships between the elements of an investment
  - Formal model
    - formal relationships between elements of an investment


High
175m
150m
100m
75m
50m
25m
10m
5m
3m
1m
Severity
Terrorism
Tornado
Earthquake
Mold
Property
Liability
Reputation Risk
Political Risk
Foreign Exchange
Risk
Credit Risk
Interest Rate Risk
Inventory Theft
IT System Failure
Intellectual
Property Piracy
Workers'
Compensation
E-risk
Low
3
5
10
15
25
50
100
200
400
High
Frequency
(Annual Events)
Hazard Risks
Financial Risks
Business Risks
Operational Risks

Risk Identification Tools

- Checklists, questionnaires, surveys
- Personal Interviews
- Performance standards checks
- Process flow analysis – routine inspections and quality control measures
- Audits – both internal and external
- Specialized Computer software
- Team approaches – brainstorming
- Claims history
- Insurance records

Risk Identification Techniques

- Interview with SME's
- Brainstorming
- Delphi Technique
- Nominal Group Technique
- Crawford Slip
- Analogy
- SWOT
- Cause & Effect Diagram

Methods of reducing risk:

- avoid risk
  - ✖ discontinue investment in high risk projects
- reduce risk
  - ✖ diversify = spread risk into many investments/projects
  - ✖ compensate = hedging
- transfer risk to insurer or subcontractors
- finance risk = cover risk with equity.

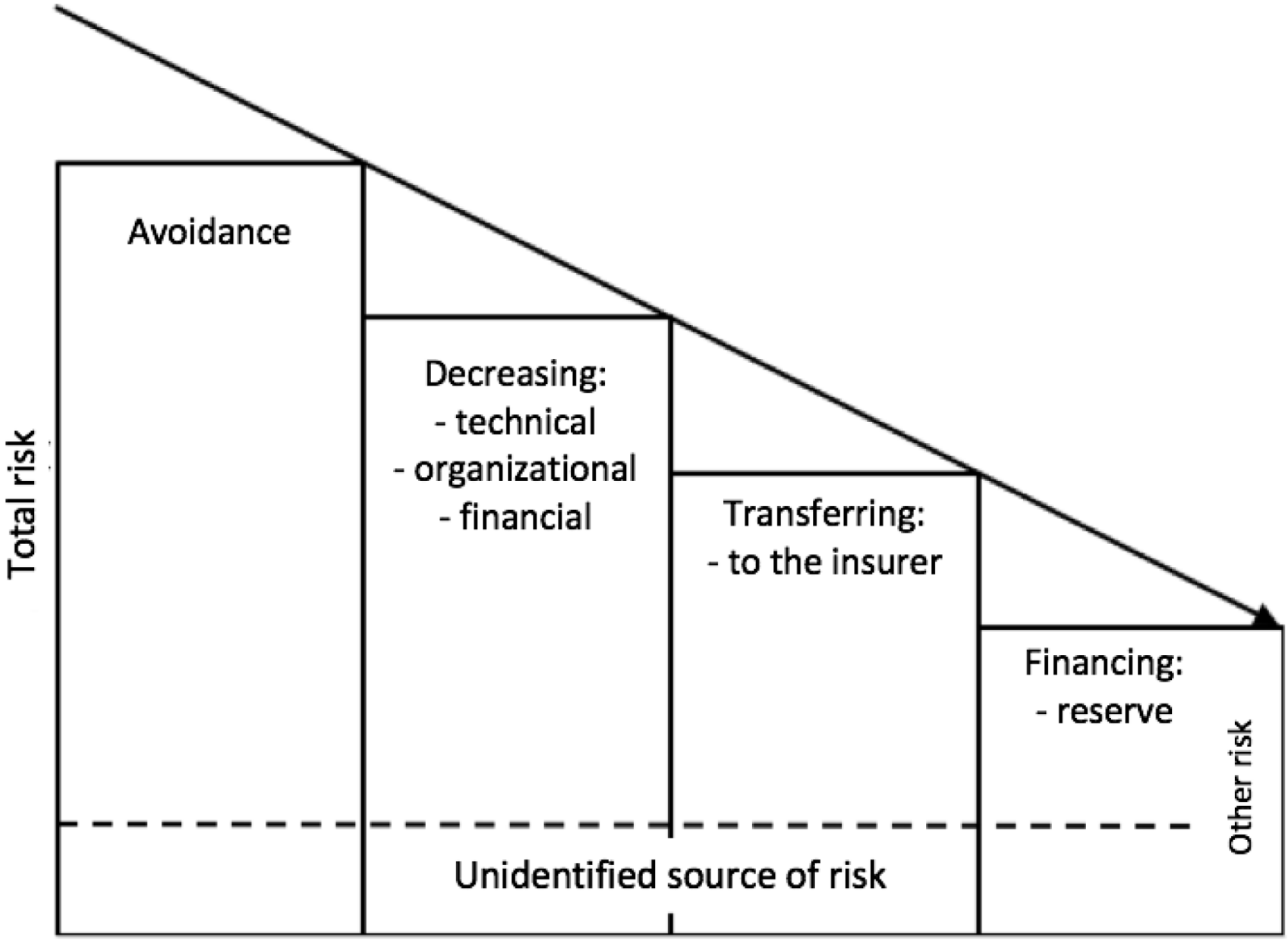
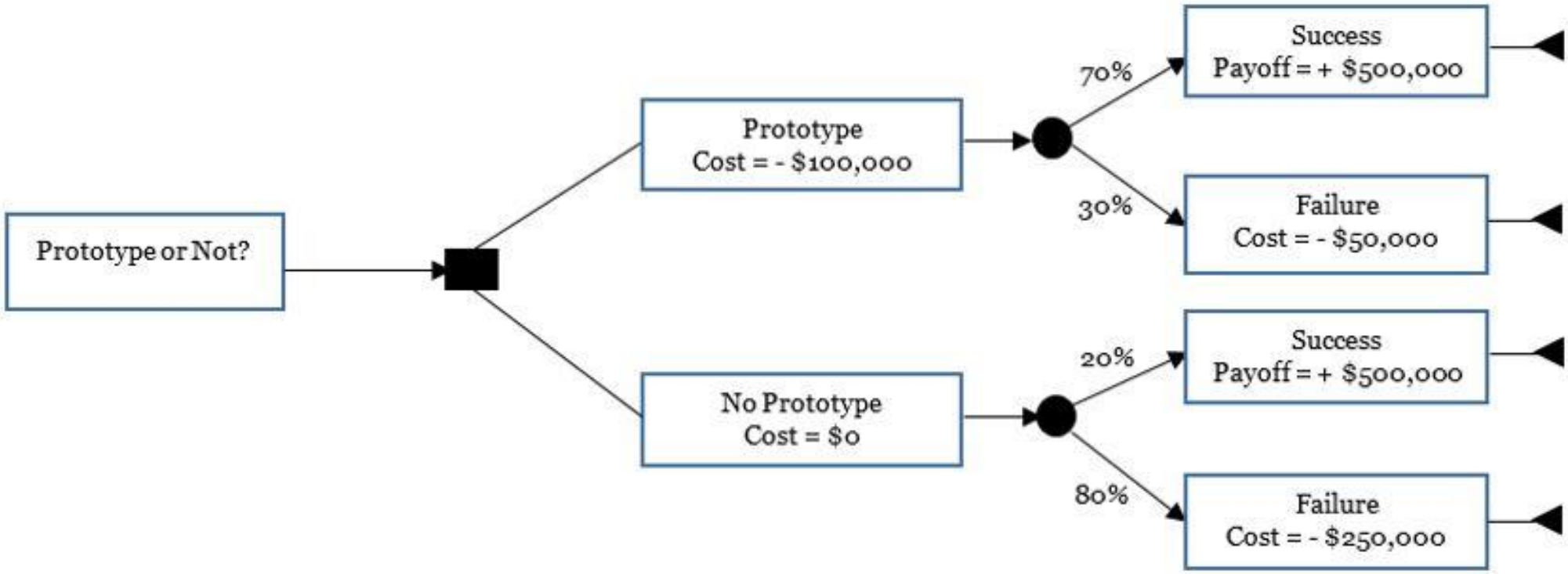
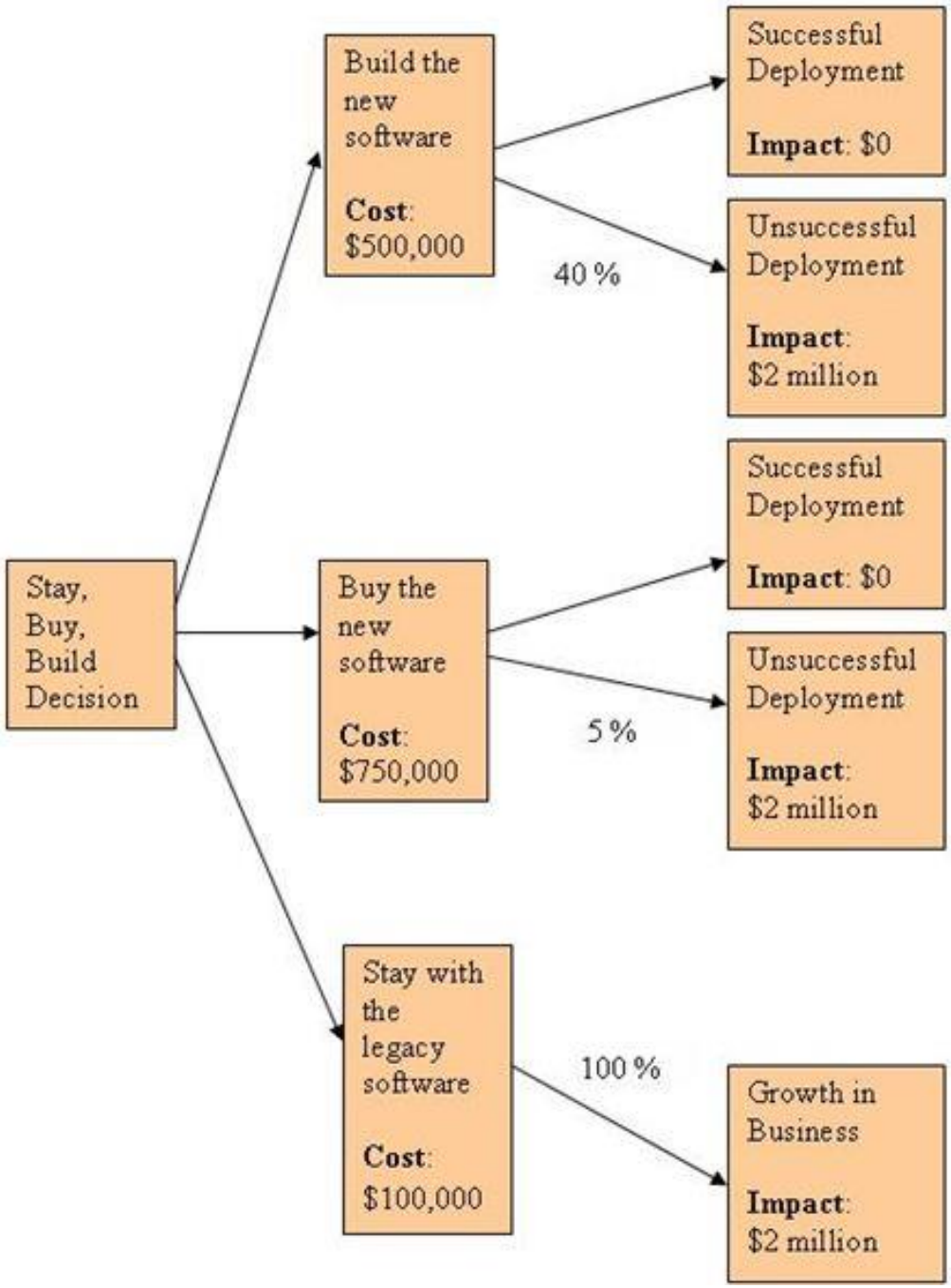


Fig. 2. Risk management (Zachorowska 2006)

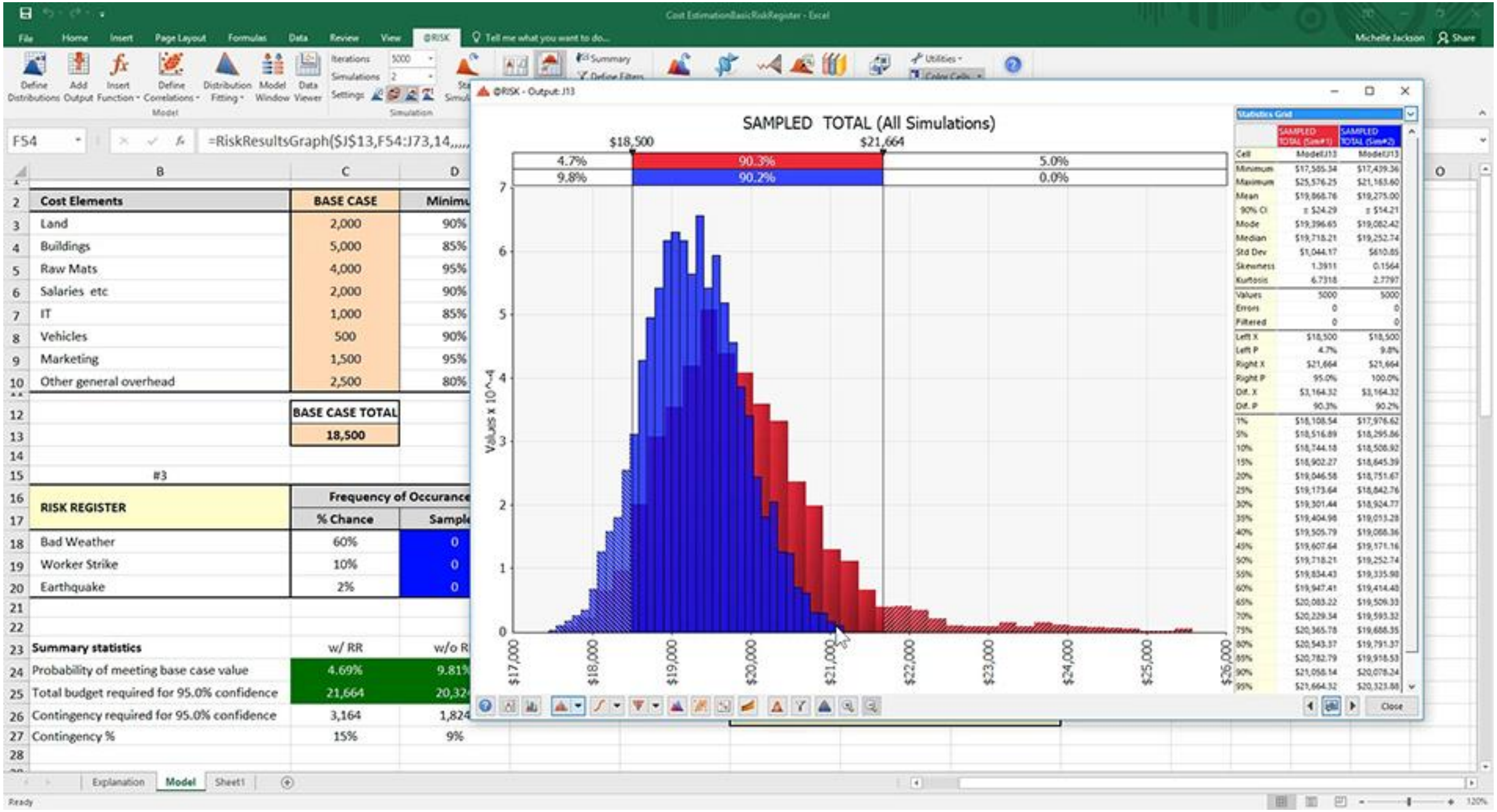
Methods of quantifying risk:

- Financial
  - discount rate
    = standard (risk-free) rate + inflation + risk premium
  - Net Present Value (NPV)
  - Internal Rate of Return (IRR)
- Sensitivity (analysis)
  - combined with financial (NPV & IRR) methods
- Decision making trees
- Networks
- Experts


Prototype or Not?
Prototype
Cost = - $100,000
No Prototype
Cost = $0
70%
30%
20%
80%
Success
Payoff = + $500,000
Failure
Cost = - $50,000
Success
Payoff = + $500,000
Failure
Cost = - $250,000


Stay, Buy, Build Decision
Build the new software
Cost: $500,000
40 %
Successful Deployment
Impact: $0
Unsuccessful Deployment
Impact: $2 million
Buy the new software
Cost: $750,000
5 %
Successful Deployment
Impact: $0
Unsuccessful Deployment
Impact: $2 million
Stay with the legacy software
Cost: $100,000
100 %
Growth in Business
Impact: $2 million

- Statistical
- Probabilistic
  - Value at Risk (VaR), uses statistical distributions
    - historical method
    - variance method
    - Monte Carlo method
- Simulation
  - Monte Carlo method = repeated sampling.



Cost EstimationBasicRiskRegister - Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
@RISK
Tell me what you want to do...
Michelle Jackson
Share
Define Distributions
Add Output
Insert Function
Define Correlations
Distribution Fitting
Model Window
Data Viewer
Iterations
5000
Simulations
2
Settings
Model
Simulation
Summary
Define Filters
Utilities
F54
=RiskResultsGraph(J13,F54:J73,14,...
@RISK - Output: J13
SAMPLED TOTAL (All Simulations)
$18,500
$21,664
4.7%
90.3%
5.0%
9.8%
90.2%
0.0%
Values x 10^-4
$17,000
$18,000
$19,000
$20,000
$21,000
$22,000
$23,000
$24,000
$25,000
$26,000
Statistics Grid
SAMPLED TOTAL (Sim#1)
SAMPLED TOTAL (Sim#2)
Close
Cost Elements
BASE CASE
Minimu
Land 2,000 90%
Buildings 5,000 85%
Raw Mats 4,000 95%
Salaries etc 2,000 90%
IT 1,000 85%
Vehicles 500 90%
Marketing 1,500 95%
Other general overhead 2,500 80%
BASE CASE TOTAL
18,500
#3
RISK REGISTER
Frequency of Occurance
% Chance
Sample
Bad Weather 60% 0
Worker Strike 10% 0
Earthquake 2% 0
Summary statistics
w/ RR
w/o R
Probability of meeting base case value 4.69% 9.81%
Total budget required for 95.0% confidence 21,664 20,32
Contingency required for 95.0% confidence 3,164 1,824
Contingency % 15% 9%
Explanation
Model
Sheet1
Ready

The Monty Hall Problem

https://www.mathwarehouse.com/monty-hall-simulation-online/

Example of agricultural biogas plant:

- Mesophyll digestion,
- Single-stage fermentation,
- High performance cogeneration,
- The installed electrical capacity – 2 MW,
- The expected life – 20 years,
- The investment in the investor's premises,
- Substrates from animal husbandry carried out in the investor's farm,
- Corn silage and other vegetable waste available in the market at the price of PLN 80 /ton,
- The annual biogas plant operation time – 8000 h,
- Thermal efficiency – about 45%,
- Electrical efficiency – about 40%,
- The use of digestate pulp on own fields,
- The area adapted to the implementation of this type of investment,
- The unit cost is PLN 13 million/MW,
- Additional one-time costs of PLN 410 000.

The values characterizing the investment were calculated on the basis of the above assumptions. The gas production is around 7,300,000 m^3/ year (≈4 383 000 m^3 methane per year). The electric power is 2 MW and the thermal power is 2.25 MW, of which 9% and 21% are consumed for own needs of the system, respectively.

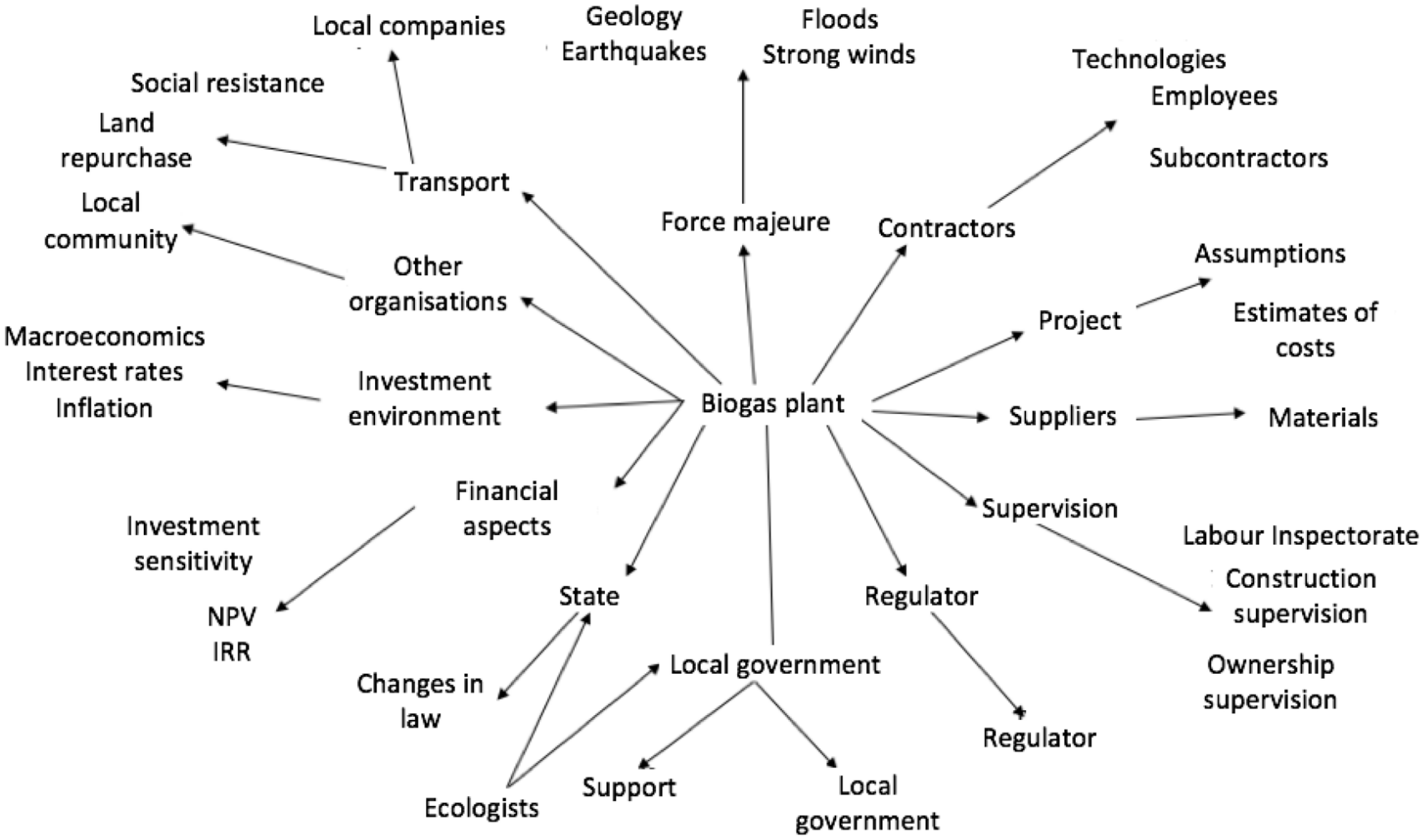


Fig. 3. The simplified "Large drawing analysis" for biogas plant

Example uses

- Monte Carlo simulation
- NPV indicator
  - 1000 random samples
  - NPV probability distribution
- VaR
  - 95% confidence level

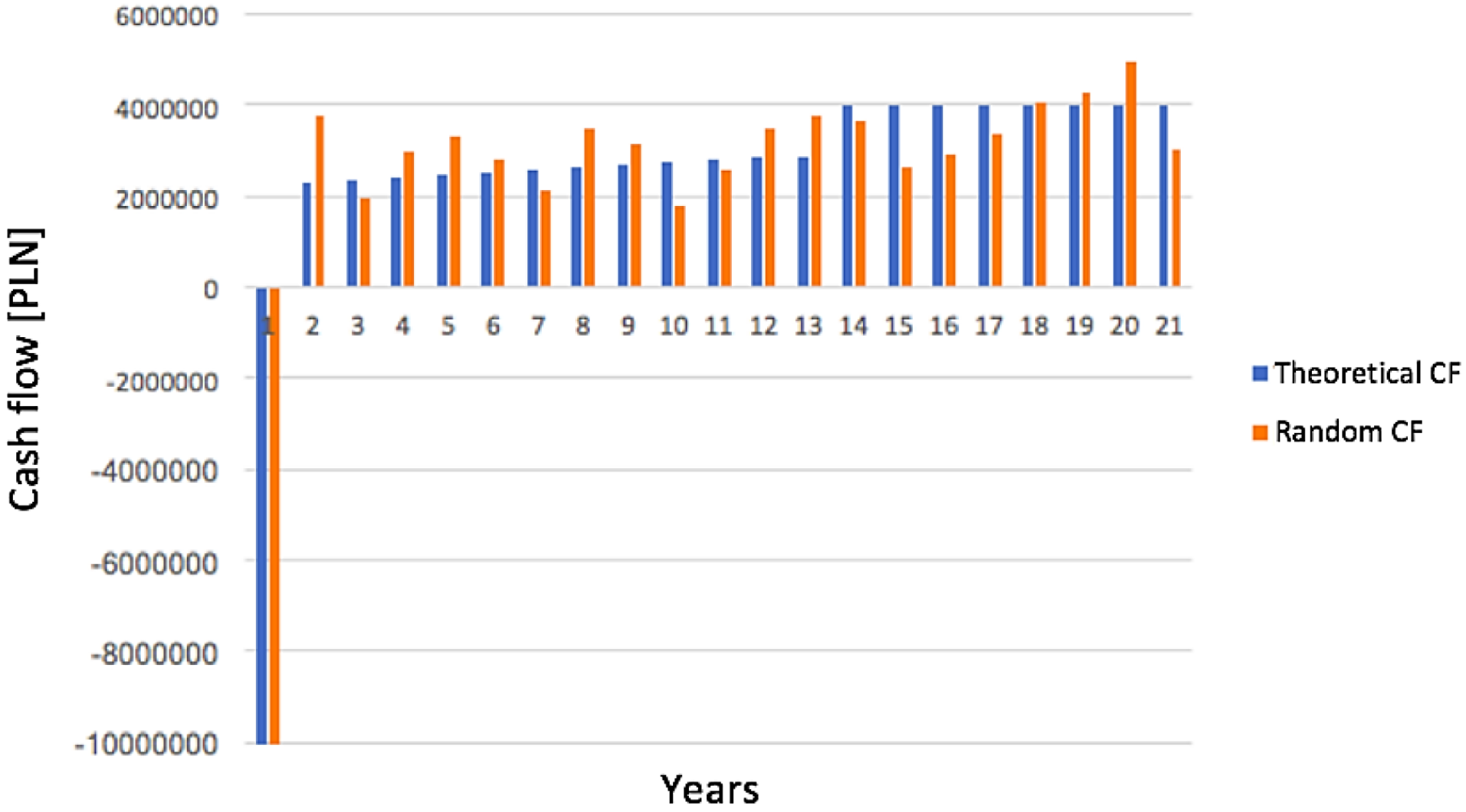


Fig. 4. The theoretical and exemplary, based on the Monte Carlo method, cash flow chart

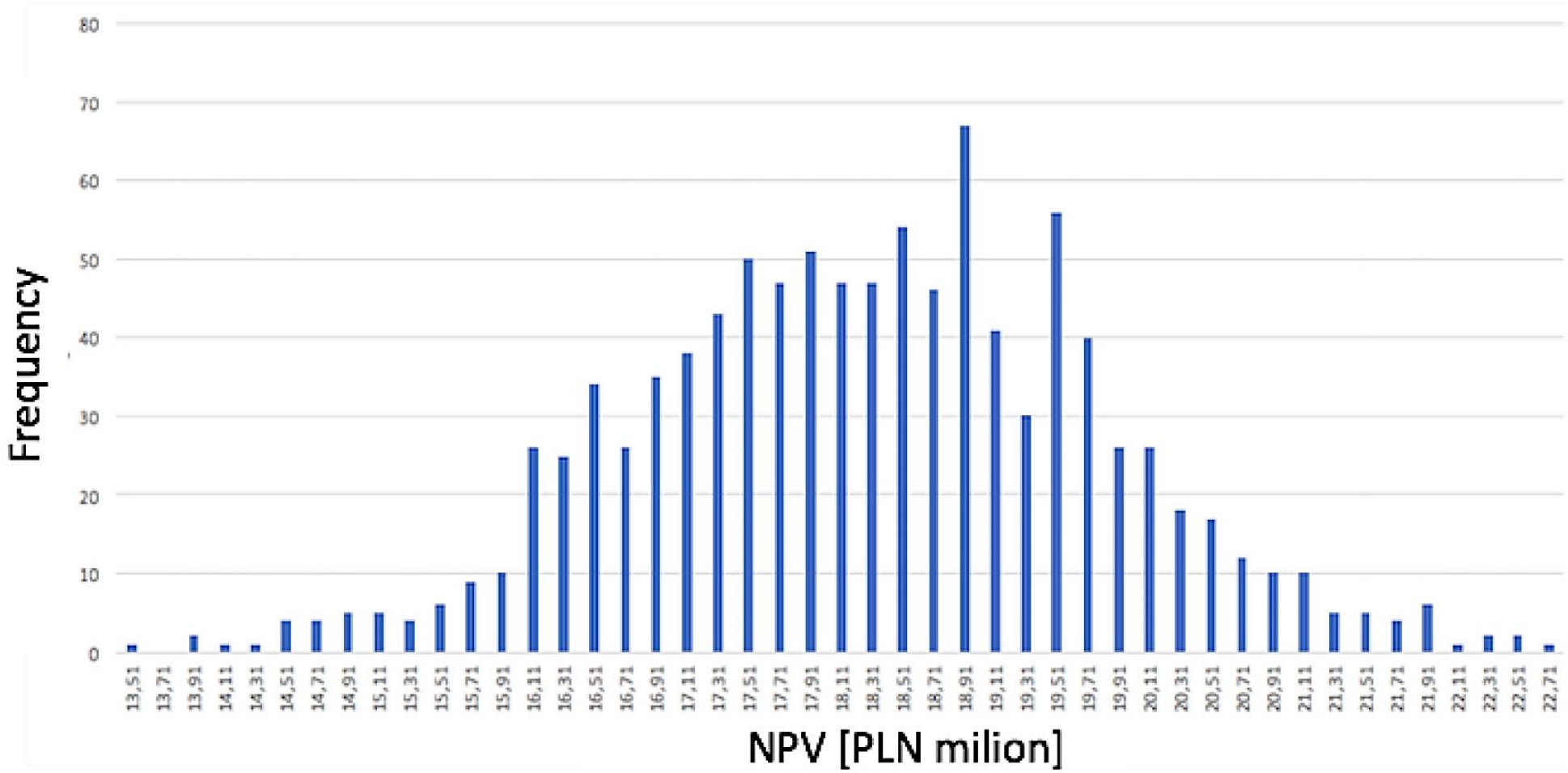


Fig. 5. The histogram of the frequency of specific ranges of NPV values

TABLE 2. Monte Carlo simulation results [PLN]

TABELA 2. Wyniki symulacji Monte Carlo [zł]

The average NPV	18,193,050.6
The standard deviation of NPV	1,491,947.6
The standard error of average NPV	47,179.5
NPV median	18,217,334.4
Skewness	–0.020
Range	9,201,124.1
Minimum	13,488,995.3
Maximum	22,690,119.4

TABLE 3. Results of VaR calculations

TABELA 3. Wyniki obliczeń VaR

Average NPV (PLN)	18,193,050.6
The standard deviation of NPV (PLN)	1,491,947.6
The confidence level	0.95
VaR (PLN)	2,454,035.4

Conclusions on agricultural biogas plant:

- negative financial result is unlikely
- investment risk is low.